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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/810,415	03/25/2004	Miika Leinikka	ASMMC.057AUS	8921

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EXAMINER

CHAMBLISS, ALONZO

ART UNIT	PAPER NUMBER
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2814

DATE MAILED: 07/31/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/810,415	Applicant(s) LEINIKKA ET AL.	
	Examiner Alonzo Chambliss	Art Unit 2814	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 02 May 2006.
2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-52 and 63 is/are pending in the application.
4a) Of the above claim(s) _____ is/are withdrawn from consideration.
5) ☐ Claim(s) _____ is/are allowed.
6) ☒ Claim(s) 1-52 and 63 is/are rejected.
7) ☐ Claim(s) _____ is/are objected to.
8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
10) ☒ The drawing(s) filed on 02 May 2006 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

1. The amendment filed on 5/2/06 has been fully considered and made of record in the instant application.

Response to Arguments

2. Applicant's arguments filed 5/2/06 have been fully considered but they are not persuasive.

In regards to Claim 1 failing to disclose oxidizing a top layer of the diffusion barrier. The claim does not recite how the oxidizing step of the diffusion layer is performed. Soininen teaches oxidizing a top layer of a diffusion layer in an ALD chamber by growing a metal oxide on the diffusion layer 14 (see col. 7 lines 21-37).

In regards to Soininen failing to teach "reducing an oxidized portion of the diffusion layer" is not recited in the claim. **Reducing the oxidation state of the metal oxide layer to form a first seed layer** is recited in the claim. Soininen teaches this claim limitation in col. 7 lines 33-37.

In regards to Soininen failing to teach "depositing a conductor over the nucleation layer". Soininen teaches depositing a conductor (i.e. a second Cu seed layer as seen in col. 2 lines 7-15) directly on the first seed layer 16 in Fig. 1).

In regards to Elers failing to disclose a three component diffusion barrier. Elers discloses a three-component diffusion barrier a diffusion barrier comprising tungsten carbide or tungsten nitride carbide layer by ALD (see pages 5, 9, and 10, claims 1-9).

In regards to Elers failing to disclose “ forming a tungsten nitride carbide diffusion barrier on a substrate”. First, applicant states that on page 13 Elers discloses a ternary material (i.e. a material made of three components). Second, one skilled in the art based on the metal components (i.e. tungsten nitride) and a carbide component of Elers, would provide a barrier layer including a tungsten nitride carbide formed by a ALD process.

Drawings

3. The drawings were received on 5/2/06. These drawings are approved by the examiner.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 1-4, 10-13, 15-19, 21-24, 28, 33-37, 48, 49, 52, and 63 insofar as definite are rejected under 35 U.S.C. 102(b) as being clearly anticipated by Soininen et al. (US 6,482,740).

With respect to Claims 1, 19, 33, 48, 49, and 63, Soininen teaches depositing a diffusion barrier 14 on a substrate and oxidizing a top layer of the diffusion barrier 14 to form a metal oxide layer 16 (i.e. nucleation layer). A preparation process on the substrate is done to form a nucleation layer 16. The preparation process is done when

n = 1 - 10. Reducing the oxidation state of the metal oxide layer 16 to form a first seed layer 16 and depositing a conductor (i.e. a second Cu seed layer as seen in col. 2 lines 7-15) directly on the first seed layer 16 (see col. 1 lines 25-47, col. 5 lines 45-52, and col. 6 lines 25-50).

With respect to Claim 2, Soininen teaches depositing a diffusion barrier layer comprises an atomic layer deposition process (see col. 6 lines 27-54).

With respect to Claims 3 and 4, Soininen teaches depositing a diffusion barrier comprises a tantalum nitride layer (see col. 5 lines 45-58).

With respect to Claim 10, Soininen teaches wherein oxidizing the top layer of the barrier layer comprises exposing the barrier layer to an oxygen source chemical (see col. 6 lines 35-55).

With respect to Claim 11, Soininen teaches wherein the oxygen source is hydrogen peroxide (see col. 11 lines 26-32).

With respect to Claim 12, Soininen teaches repeating oxidizing and reducing the top of the barrier layer before depositing the conductor directly on the first seed layer (see claims 22 and 24).

With respect to Claim 13, Soininen teaches wherein oxidizing and reducing the top of the barrier layer is repeated between about 10 and 50 times (see claim 24).]

With respect to Claims 15-18, 34, and 35, Soininen teaches wherein depositing the conductor comprises depositing a second seed layer (i.e. ruthenium) by ALD (see col. 5 lines 1-14). Thus, allowing the copper to be deposited directly over the second seed layer.

With respect to Claims 21, 22, and 52, Soininen teaches wherein depositing copper comprises an electrochemical deposition, electroless, or CVD process (see col. 3 lines 15-17).

With respect to Claim 23, Soininen teaches wherein reducing comprises reducing the metal oxide to an elemental metal form (see col. 5 lines 10-14, col. 6 lines 40-42 and col. 7 lines 35-37).

With respect to Claims 24 and 28, Soininen teaches wherein reducing the oxidation state comprises using hydrogen plasma and exposing the metal oxide to a gaseous compound containing a functional from the group comprising alcohol(-OH), aldehyde (-CHO), and carboxylic acid (-COOH) (see col. 11 lines 58-60 and col. 12 lines 61-65).

With respect to Claim 27, Soininen teaches wherein the reducing the oxidation state comprises an electrochemical process (i.e. current applied to the metal) (see col. 3 lines 15-35).

With respect to Claim 36, Soininen teaches wherein the preparation process comprises exposing the substrate to a pulse of oxygen in a reactor chamber, purging the reactor chamber with an inert gas, exposing the substrate to a pulse of hydrogen, and purging the reactor chamber with an inert gas (see col. 6 lines 55-67 and col. 7 lines 20).

With respect to Claim 37, Soininen teaches exposing the substrate to a pulse for a ruthenium source chemical and purging the reactor chamber before exposing the

substrate to the oxygen pulse (see col. 6 lines 25-67, col. 7 lines 20-67, and col. 8 lines 1-67).

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

7. Claims 5-9, 14, 25, 26, 29-32, 44-47, 50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. (US 6,482,740) as applied to claims 1 and 33 above, and further in view of Elers et al. (WO 01/29893).

With respect to Claims 5-9 and 29, Soininen discloses the claimed invention except for the diffusion barrier comprising tungsten carbide or tungsten nitride carbide layer. However, Elers discloses depositing a diffusion barrier comprising tungsten

carbide or tungsten nitride carbide layer by ALD (see pages 5, 9, 10, and 13; claims 1-9). Thus, Soininen and Elers have substantially the same environment of a barrier layer deposited on a substrate by ALD. Therefore, one skilled in the art at the time of the invention would readily recognize substitute the barrier film including tungsten nitride carbide for the barrier including nitride layer of Soininen, since the barrier film including tungsten nitride carbide would facilitate high quality ultra thin layer while providing a corrosion protection for the substrate as taught by Elers.

With respect to Claims 14 and 50, one skilled in the art would readily recognize oxidizing and reducing the top of the barrier layer is repeated between about 20 and 40 times, since repeated steps would define the desired thickness of the barrier layer base the need of the semiconductor device.

With respect to Claims 25, 26, 44, and 45, one skilled in the art at the time of the invention would readily recognize substituting either an in-situ or remote hydrogen plasma for the hydrogen plasma, since both process would provide a stable method of for creating a seed layer on the barrier layer with a controlled rate.

With respect to Claims 30-32, Soininen discloses wherein depositing the conductor comprises depositing a second seed layer (i.e. ruthenium) by ALD over a first seed layer (see col. 5 lines 1-14).

With respect to Claim 46 and 47, Elers discloses the diffusion barrier layer comprising a tungsten nitride carbide or molybdenum nitride carbide (see pages 5, 9, and 10, claims 1-9).

8. Claims 20 and 51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. (US 6,482,740) as applied to claim 1, and further in view of Chen et al. (US 6,753,249).

With respect to Claims 20 and 51, Soininen fails to disclose depositing copper by electrochemical deposition process. However, it is well known in the semiconductor industry that copper can be deposited by electrochemical deposition as evident by Chen (see col. 5 lines 14-17). Therefore, it would have been obvious to one substitute electrochemical deposition for electroless deposition since the electrochemical deposition would provide a reliable process to fill the trench as taught by Chen.

9. Claim 38-43 are rejected under 35 U.S.C. 103(a) as being unpatentable over Soininen et al. (US 6,482,740) as applied to claims 33 and 36, and further in view of Aaltonen et al. (US 2003/0165615).

With respect to Claims 38-43, Soininen fails to explicitly recite the pulse of hydrogen and oxygen. However, it is well known in the semiconductor industry to have a hydrogen and oxygen pulse of 10 seconds or more as evident by Aaltonen (see paragraphs 53, 55, and 60, claims 1 and 11). Therefore, it would have been obvious to one skilled in the art to incorporate a pulse of 10 seconds or more with the process of Soininen, since the pulse would yield desired thickness of the film layer in an ALD environment as taught by Aaltonen.

The prior art made of record and not relied upon is cited primarily to show the product of the instant invention.

Conclusion

10. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the mailing date of this final action.

Any inquiry concerning the communication or earlier communications from the examiner should be directed to Alonzo Chambliss whose telephone number is (571) 272-1927.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 308-7956

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PMR or Public PMR. Status information for unpublished applications is available through Private PMR only. For more information about the PMR system see <http://pair-dkect.uspto.gov>. Should you

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have questions on access to the Private PMR system contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free) or EBC_Support@uspto.gov.

AC/July 24, 2006

A handwritten signature in black ink, appearing to read "Alonzo Chambliss". The signature is fluid and cursive, with the first name "Alonzo" and last name "Chambliss" clearly distinguishable.

Alonzo Chambliss
Primary Patent Examiner
Art Unit 2814

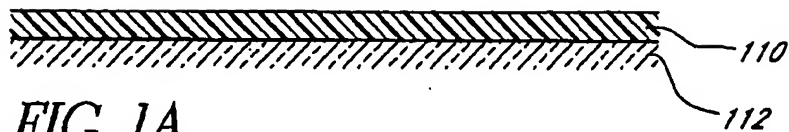


FIG. 1A

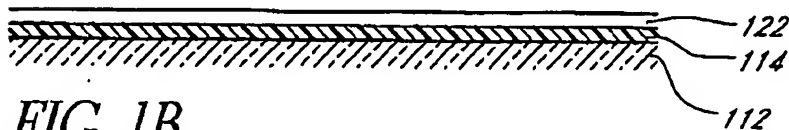


FIG. 1B

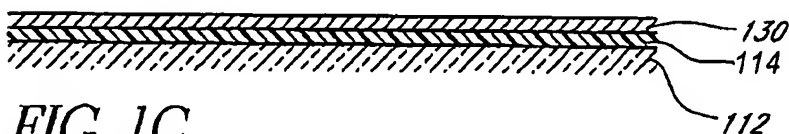


FIG. 1C

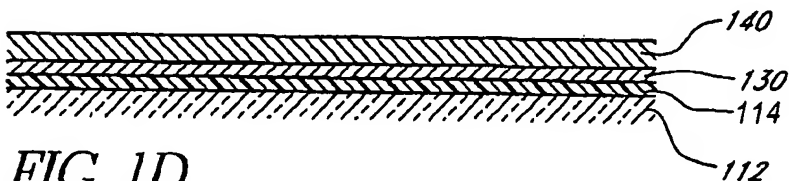


FIG. 1D

Approved
AC
7/24/06

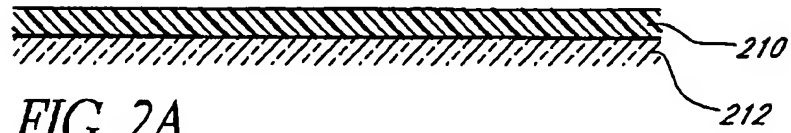


FIG. 2A

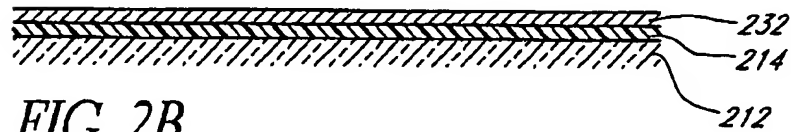


FIG. 2B

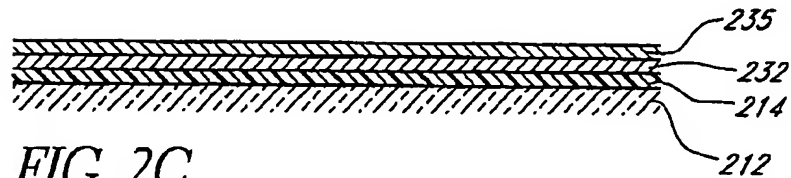


FIG. 2C

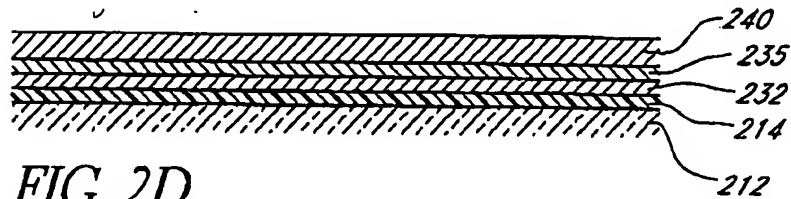
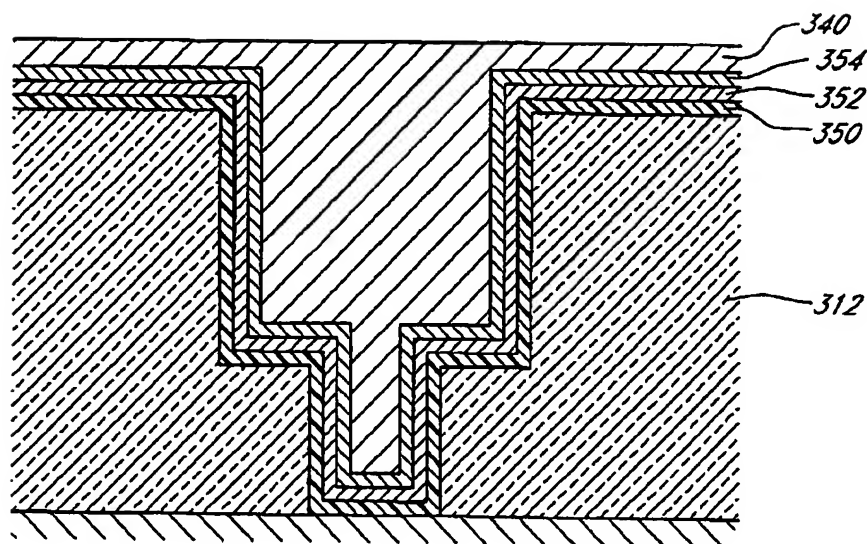


FIG. 2D

FIG. 3A



A cross-sectional view of a semiconductor device. A substrate 312 is shown at the bottom, indicated by diagonal hatching. A trench 340 is formed in the substrate, with its bottom surface indicated by dashed lines. The trench 340 has a complex, stepped profile. The inner walls of the trench are coated with a layer 350, which is further defined by a layer 352. A label 354 points to a specific feature on the inner wall of the trench.